# Myoelectric Control for a Quadriplegic*

by

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As long ago as 1952 the possible use of myoelectric signals for controlling a prosthesis was investigated by Berger and Huppert;[1] in 1955, Battye, Nightingale, and Whillis demonstrated the feasibility of such control.[2] Further developments resulted in the construction of the "Russian Hand" [3] and similar devices elsewhere, including one commercially available now in the United States.[4]

There was also some discussion of the need for such a control system for orthotic devices. But, although the feasibility of controlling hand splints by myoelectric signals was demonstrated in Houston [5] and Cleveland,[6] there was little other use of this technique until very recently, except in the earlier pioneering work at Vanderbilt [7] [8] where poliomyelitis patients were enabled to control their respirators. While the present report was being written, an article appeared in this Journal describing recent achievements in Cleveland;[9] this report presents our own first fitting to a quadriplegic.

Our subject was 15 years old in 1956 and a passenger in a pickup truck which went out of control and rolled over several times. He suffered a spinal cord lesion at the C4, 5 level and so was immediately quadriplegic. He did manage to finish high school, but was unable to go on to college. After ten years of complete dependence on others for his care, he came to Rancho Los Amigos Hospital in November, 1966. It was believed that orthotic devices developed within the past few years could give him sufficient physical assistance to permit his going on to college and in other ways living a fuller life.

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On arrival at Rancho Los Amigos Hospital he presented on the right side a fair-to-good trapezius and deltoid, with good biceps and fair plus brachioradialis and supinators. Below this he had no strength except a trace in the long wrist extensor. On the left he had zero deltoid, fair plus to good trapezius, nothing but a trace biceps below the shoulder. It was decided to fit him with an electrically powered flexor hinge hand splint on the right.

He seemed a good candidate for myoelectric control of the splint, since signals from the wrist extensor could in principle be used to control the action just as with the usual wrist-driven splint: an easily-learned, rather normal wrist motion. But examination for myoelectric activity showed that during the years post onset, having no functional use of the wrist extensor, he had lost isolated control and now used the extensor simultaneously with the supinator. This caused signals whenever he supinated and would have given undesired opening or closing of the splint. Since the left arm was not expected to be functional, it was decided to utilize control signals from the left biceps. We felt it was important not to select a muscle which would be used in other motions and so give undesired signals.

Figure 1 shows the electrode assembly which is used; the larger metal plate is a ground or reference electrode, and signals from the two textured domes go into the differential amplifier of the input circuit. The control circuit, shown in **Figures 2** and **3**, was developed here. It uses a three-level control from the single muscle, like the circuit of Dorcas and Scott.[10] A small effort closes the splint, a moderate one opens it, and relaxation causes it to hold whatever position it is in. The levels of effort were adjusted to the subject's preference. The batteries, motor, and control circuitry are at his left in **Figure 4**; the electrode strap can be seen on his left biceps.

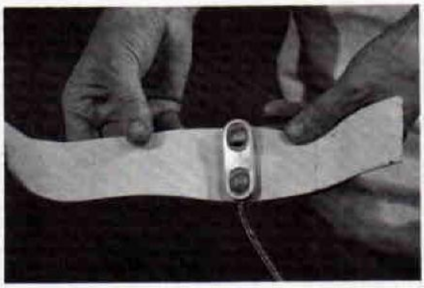

**FIGURE 1—Surface electrodes used over left biceps.**

Because the myoelectric control was new and he lived some distance from this Hospital, he was also given a shoulder switch control as an alternative if some trouble should occur. He was trained in the use of each control. Evaluation after a month's training showed his performance in various test tasks requiring grasping and transferring objects was about equivalent by each control system. One major advantage of the myoelectric control is that he does not have to maintain a particular position in his

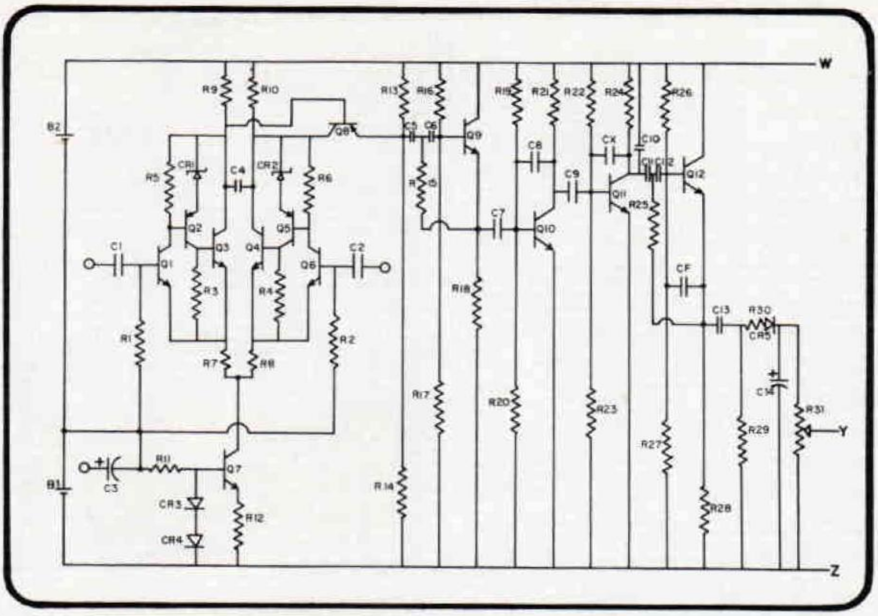


**FIGURE 2—Control circuitry, input and amplification.**

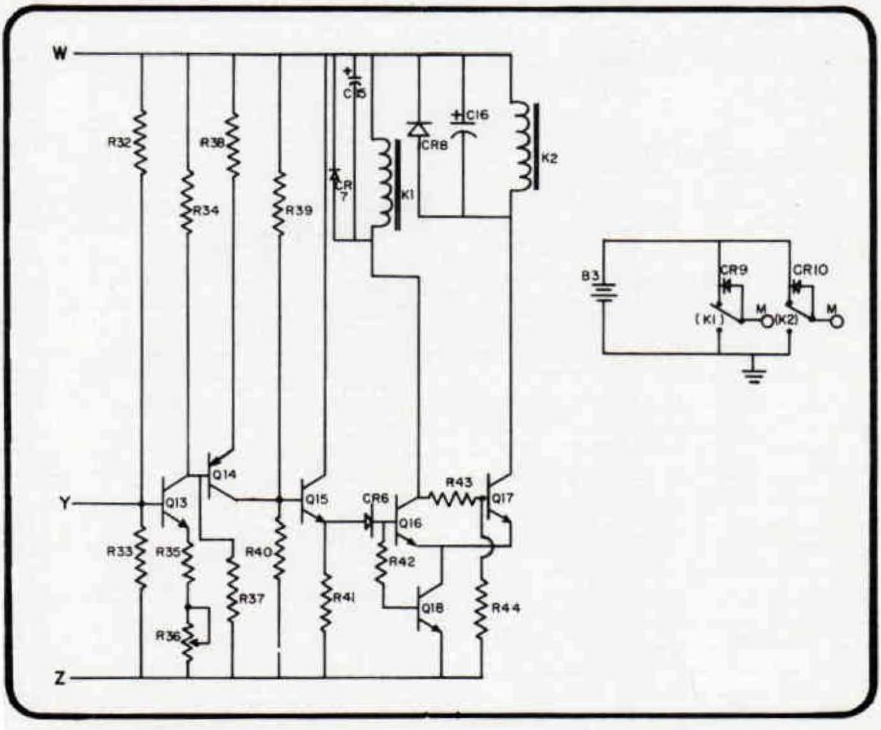


**FIGURE 3—Control circuitry, level separation and output to relays. Signal circuit is separated from motor circuit by relays.**

wheelchair in order to operate the control; he can shift his position, and can even wear the myoelectric control in bed or wherever he wishes. On the other hand, his electric razor generates so much electrical interference so close to the electrodes and circuitry as to cause trouble. Also, leaning forward on his left elbow causes biceps tension and unwanted signals, so this control technique is not yet a solution for all problems!

In continuing our program, implied in some earlier comments in this field,[11] we are now fitting two other people who have cervical lesions, and we plan to follow the experience of all these who have this kind of control system.

**FIGURE 4—Subject with splint, power, and controls.**

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